BRH/DEP 70 - 4

PB190876

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC® PORTABLE X-RAY SPECTROGRAPH

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service

34

DIVISION OF ELECTRONIC PRODUCTS

List of Publications

The following reports published as part of this series by the Division of Electronic Products, Bureau of Radiological Health are available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Price is $3.00 for paper copy and $0.65 for microfiche. The PB number, if indicated for a report, should be cited when ordering.

	Title	
TSB-1	Instrument for measurement of X-ray Emission from Television Sets (January 1968)	PB 178 808
TSB-2	A Pilot Survey of X-Radiation Emissions from Color Television Receivers (In Pinellas County, Florida) (June 1968)	PB 178 809
TSB-3	A Survey of X-Radiation from Color Television Sets in the Washington, D. C. Metropolitan Area (March 1968)	PB 178 810
TSB 68-4	Biological Aspects of Microwave Radiation - A Review of Hazards (July 1968) (Reprinted August 1969)	PB 185 964
TSB-5	Report of Preliminary Measurements of Electromagnetic Radiation Fields Near Microwave Ovens (December 1968)	PB 185 967
DEP 69-1	X-Radiation Control Programs in the Color Television Industry - Summary Report on Visits to Manufacturers - May 1968-December 1968 (March 1969)	PB 185-979
DEP 69-2	A Field Method for the Determination of Lead in Glass Used for Shielding Television Receiver Components (December 1969)	PB 188 703
BRH/DEP 70-1	X-ray Emission from Cold-Cathode Gas Discharge Tubes Used for Educational Purposes (February 1970)	PB 189 890
BRH/DEP 70-2	Report of Tests Made on the Westinghouse Panoramix® X-ray Machine	
BRH/DEP 70-3	Description and Evaluation of a Fluoroscopic Screen Visual Brightness Comparer	

BRH/DEP 70-4

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC® PORTABLE X-RAY SPECTROGRAPH

Ray C. Woodcock

X-ray Exposure Control Laboratory
Division of Electronic Products

March 1970

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health
Rockville, Maryland 20852

The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products by the Department of Health, Education, and Welfare, Public Health Service.

FOREWORD

The Bureau of Radiological Health, formerly the National Center for Radiological Health, continues to carry out a national program designed to reduce the exposure of man to hazardous ionizing and nonionizing radiation.

Within the Bureau, the Division of Electronic Products (1) develops and administers performance standards for radiation emissions from electronic products, (2) studies and evaluates emissions of and conditions of exposure to electronic product radiation and intense magnetic fields, (3) conducts or supports research, training, development, and inspections to control and minimize such hazards, and (4) tests and evaluates the effectiveness of procedures and techniques for minimizing such exposures.

The Bureau publishes its findings in Radiological Health Data and Reports (a monthly publication), the Environmental Health Series, Public Health Service numbered reports, appropriate scientific journals, and Division technical reports.

The technical reports of the Division of Electronic Products (DEP) allow comprehensive and rapid publishing of the results of intramural and contractor projects. The reports are distributed to State and local radiological health program personnel, Bureau technical staff, Bureau advisory committee members, university radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are also included in the collections of the Library of Congress and the Clearinghouse for Federal Scientific and Technical Information.

I encourage the readers of these reports to inform the Bureau of any omissions or errors. Your additional comments or requests for further information are also solicited.

John C. Villforth
Director
Bureau of Radiological Health

PREFACE

The "Radiation Control for Health and Safety Act of 1968" (Public Law 90-602) directs that the Secretary of Health, Education and Welfare, among other things, "study and evaluate emissions of, and conditions of exposure to, electronic product radiation....." This responsibility has been delegated to the Bureau of Radiological Health.

This report reflects the efforts of the Division to keep informed of new or unusual types of commercial X-ray equipment and to gather information related to operating characteristics and radiation exposure in the use of such equipment. Measurements made to determine physical and operating characteristics of the Pitchford Portaspec® portable X-ray spectrograph are described and the results reported. Some comments and recommendations relating to radiation safety are made.

Robert L. Elder Sc.D.
Acting Director
Division of Electronic Products

BLANK PAGE

CONTENTS

	Page
FOREWORD	iii
PREFACE	v
1. INTRODUCTION	1
2. GENERAL DESCRIPTION	1
3. DOSIMETRY	2
4. HALF-VALUE LAYER	10
5. PRIMARY RADIATION MEASUREMENTS	11
6. SECONDARY RADIATION MEASUREMENTS	11
6.1 Radiation Within Sample Holder	11
6.2 Scattered Radiation with Shoes; 2-1/2 inch Brass Pipe	14
6.3 Scattered Radiation without Shoes; 2-1/2 inch Brass Pipe	14
7. RADIATION RESULTING FROM DISCHARGE OF HIGH VOLTAGE FILTER CAPACITOR	17
8. OBSERVATIONS AND RECOMMENDATIONS	18
APPENDIX A RADIATION SAFETY RECOMMENDATIONS FOR PORTABLE X-RAY SPECTROGRAPH	19
APPENDIX B MANUFACTURER'S SPECIFICATIONS	24

FIGURES

Figure		Page
1	Portaspec laboratory and portable X-ray spectrograph	3
2	Side view of inside of detector unit	4
3	Spectrograph control panel	5
4	Two position holder for small samples	6
5	Detector unit in position over sample holder	7
6	Adjustable shoes mounted for analysis of round stock	8
7	Detector unit positioned for analysis of round bar	9
8	Iso-exposure rate contours from Portaspec operated at 1 mA	12
9	Iso-exposure rate contours from Portaspec operated at 4 mA	13
10	Secondary radiation intensity measured approximately 1/8 inch below Portaspec base. Portaspec operated without shoes at 4 mA	16

TABLES

Table		Page
1	Half-value layers and homogeneity coefficient.	10
2	Scattered radiation measurements at the end of a brass pipe with the shoes in place.	15

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC® PORTABLE X-RAY SPECTROGRAPH

1. INTRODUCTION

The investigation of materials by observing their characteristic fluorescent X radiation was begun in the late 1800's. It was not until about 1950, however, that modern fluorescence or spectrographic methods were developed. The portable X-ray spectrograph reported on in this study, the Norelco-Pitchford Portaspec®, is the first instrument designed for field use which employs an X-ray tube as the source of radiation (radioisotope X-ray sources are sometimes used for this purpose). The unit is marketed for on-the-spot warehouse sorting and checking of specifications, identification and sorting of scrap metals, and many other uses in mining and chemical plants. Because it appears to be the first of its kind, it was felt to be important that it be evaluated from a radiation safety viewpoint for the benefit of the user and persons responsible for radiation safety on a local, State, and Federal level.

The device appears to be tailored for a person who does not possess any degree of skill or knowledge of chemistry or spectrographic procedures. The operator must, however, have a knowledge of radiation safety since the exposure rates in the primary beam and under certain scatter conditions could produce a significant risk of genetic and somatic radiation damage.

The tests reported here consist primarily of an analysis of the primary X-ray beam and of scattered radiation under various conditions of use. Some additional comments and recommendations relating to radiation safety are also made.

2. GENERAL DESCRIPTION

The Norelco-Pitchford Portaspec is a portable X-ray spectrograph designed primarily for use outside the analytical laboratory for fast and accurate nondestructive analysis of industrial materials. The equipment (figure 1) consists of a power supply unit and a spectrographic unit connected by a 9-foot cable.

The power supply unit delivers 30 kVcp at 0-4 mA to the X-ray tube, which is in the spectrographic unit. All control and high voltage circuits are solid state. To guard against electrical shock, a grounding relay is provided which will not permit the power supply to be energized unless the unit is adequately grounded. A time delay prevents application of high voltage to the X-ray tube for approximately

one minute after the power supply is turned on to allow adequate filament warm-up time.

The spectrographic unit contains the X-ray tube, the optical system and the detector. A beryllium window, cathode-grounded X-ray tube with oil insulation and provision for water cooling is used with no added filtration. The optical system, which analyses the characteristic X-ray fluorescence spectrum of the sample, is composed of two collimators, a LiF analyzing crystal and a goniometer assembly. The goniometer is manually rotated. Its position is indicated on a dial which consists of a drum on which a scale is calibrated to show both the 2θ angle and the elements being analyzed. Figure 2 is a side view of the unit and the goniometer assembly. The detector is a thin-window, argon-filled geiger tube mounted on the goniometer. Its output is to a ratemeter included in the unit or to an external recorder or digital scaler. The ratemeter is calibrated to read 0-10, 0-100 or 0-1000 counts per second.

Figure 3 shows the spectrograph control panel. The panel includes the ratemeter and its control functions, the X-ray mA control, the X-ray "on" light, an overheating light, and the goniometer dial. The goniometer is rotated by a knob on the left side of the case (see figure 1). An exposure switch is located on the top of the vertical handle on the end of the case. This switch also activates the ratemeter. A second switch is located beside the X-ray beam port (figure 6) and is operated by contact with the sample being analyzed. Both switches must be depressed to activate the X-ray tube. Interlocks are provided so that the unit cannot be operated with the side panels removed.

For small samples up to 2 inches in diameter and 1 inch thick a two position sample holder is provided (figures 4 and 5). The detector head is secured in position over the holder and the interlock cable is plugged into the side of the instrument case. The unit is then controlled by a switch inside the sample holder door. The X-ray tube is turned on when the door is closed and off when it is opened.

Special adjustable shoes (figures 6 and 7) are provided for use in analyzing round stock. The shoes serve as radiation shields for the operator.

3. DOSIMETRY

With the exception of half-value layers, all radiation measurements were made using LiF TLD-100 extruded rods measuring approximately 1 mm x 6 mm. Prior to use, the dosimeters were annealed for one hour at 400° C followed by one hour at 100° C. The constant potential, beryllium window X-ray source used with the Division of Electronic Products' free-air ionization chamber system was used for calibration. An unfiltered 30-kV beam was used to simulate the output of the Portaspec. High-exposure calibrations were monitored with a Victoreen

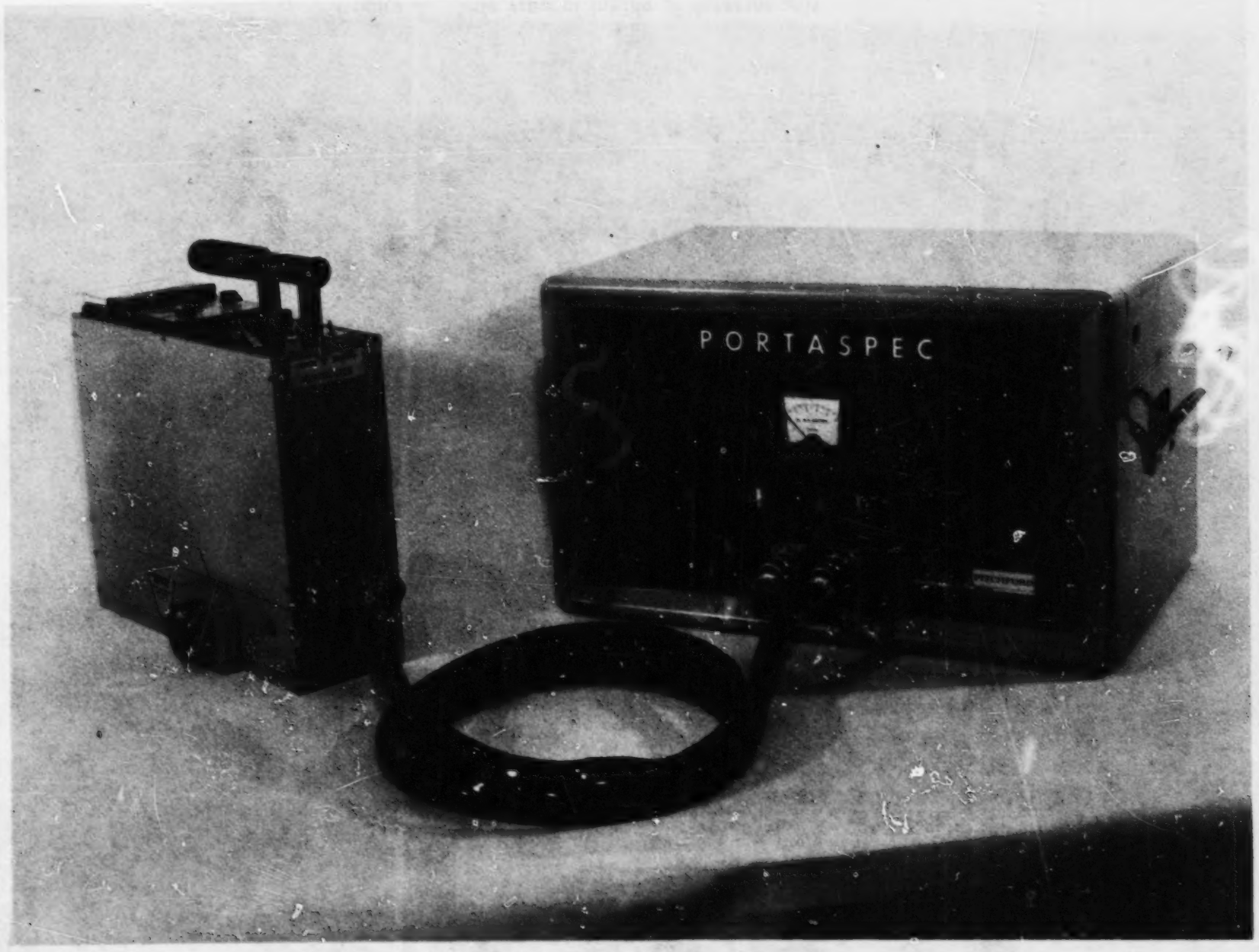


Figure 1. Portaspec® laboratory and portable X-ray spectrograph

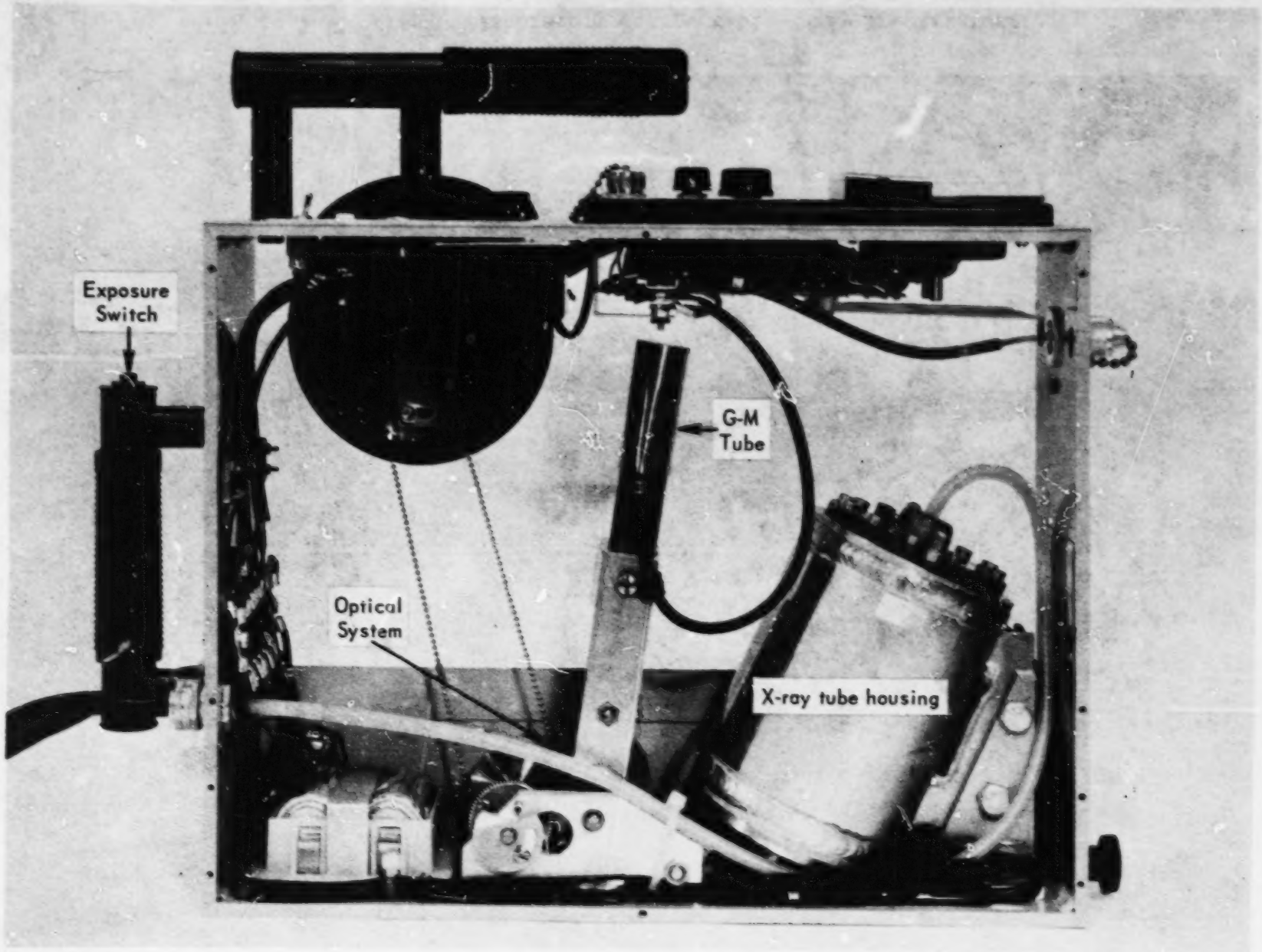


Figure 2. Side view of inside of detector unit

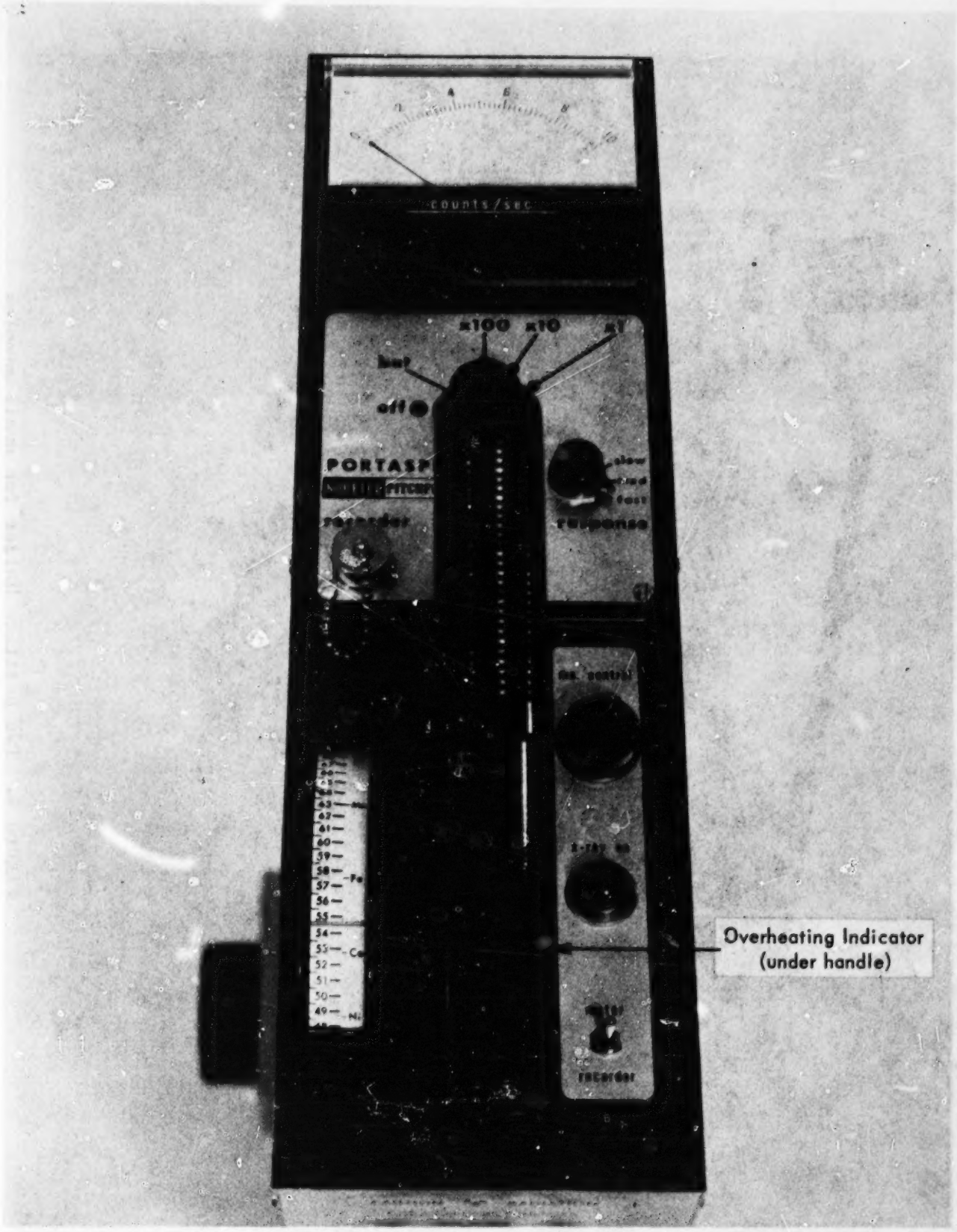


Figure 3. Spectrograph control panel

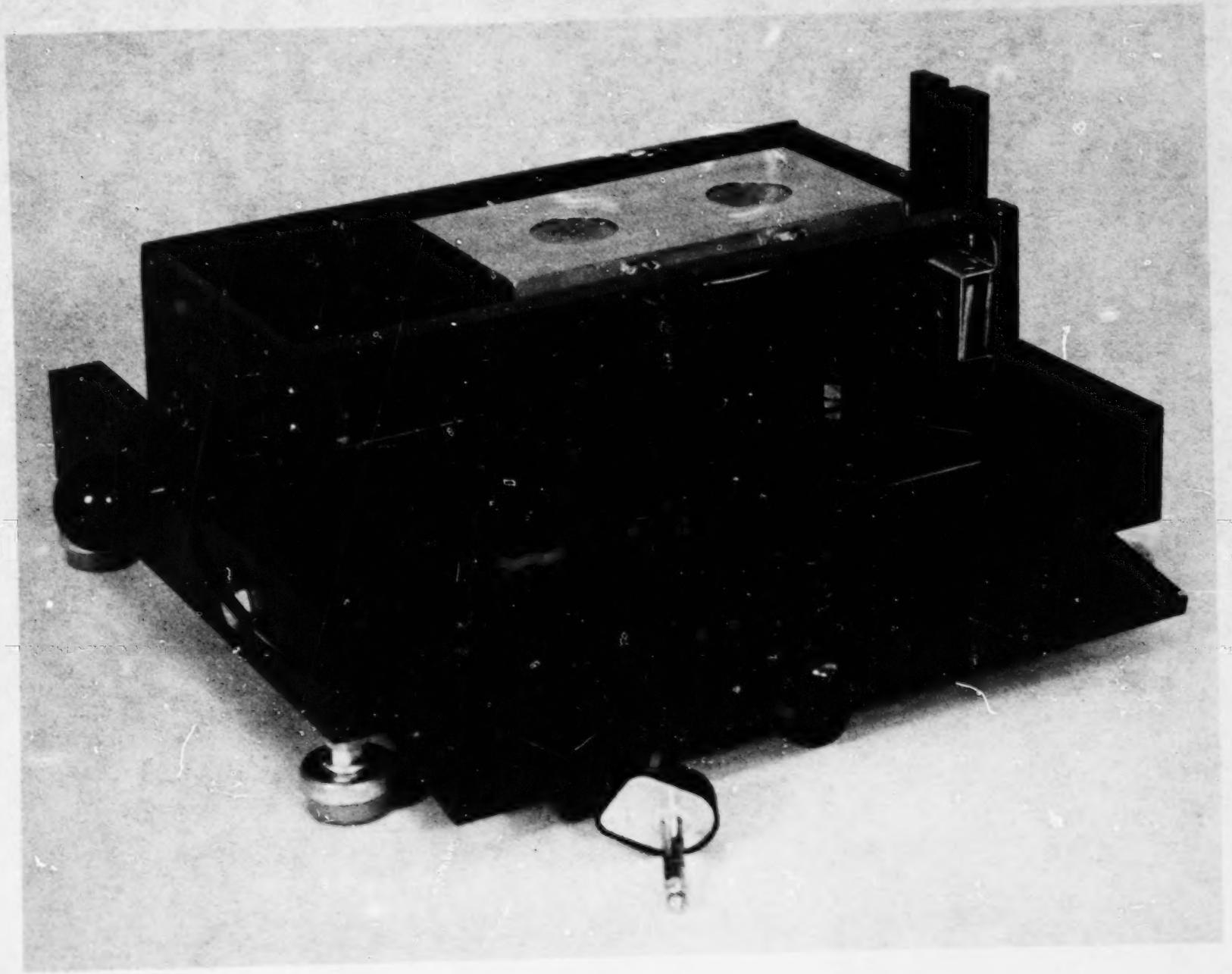


Figure 4. Two-position holder for small samples

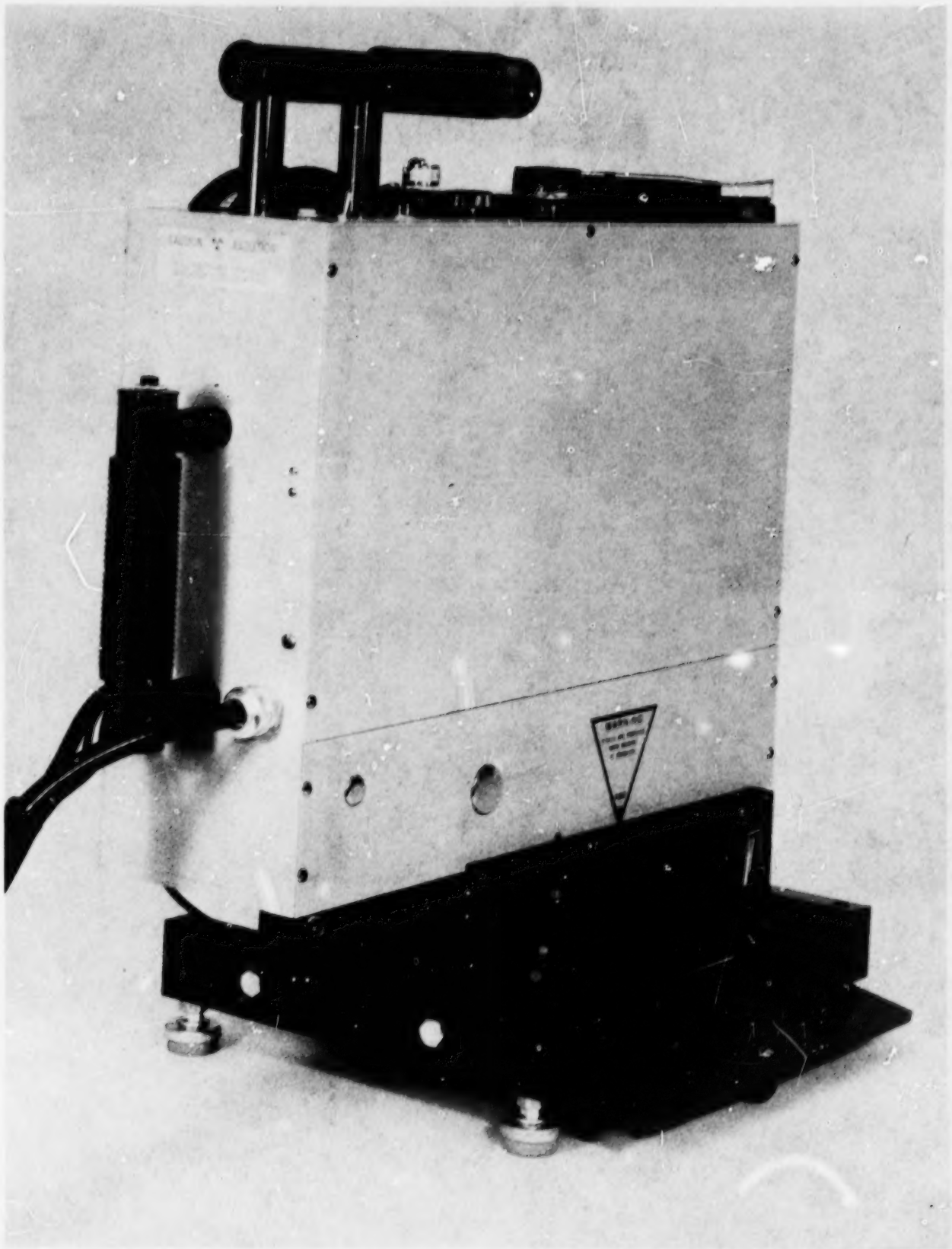


Figure 5. Detector unit in position over sample holder

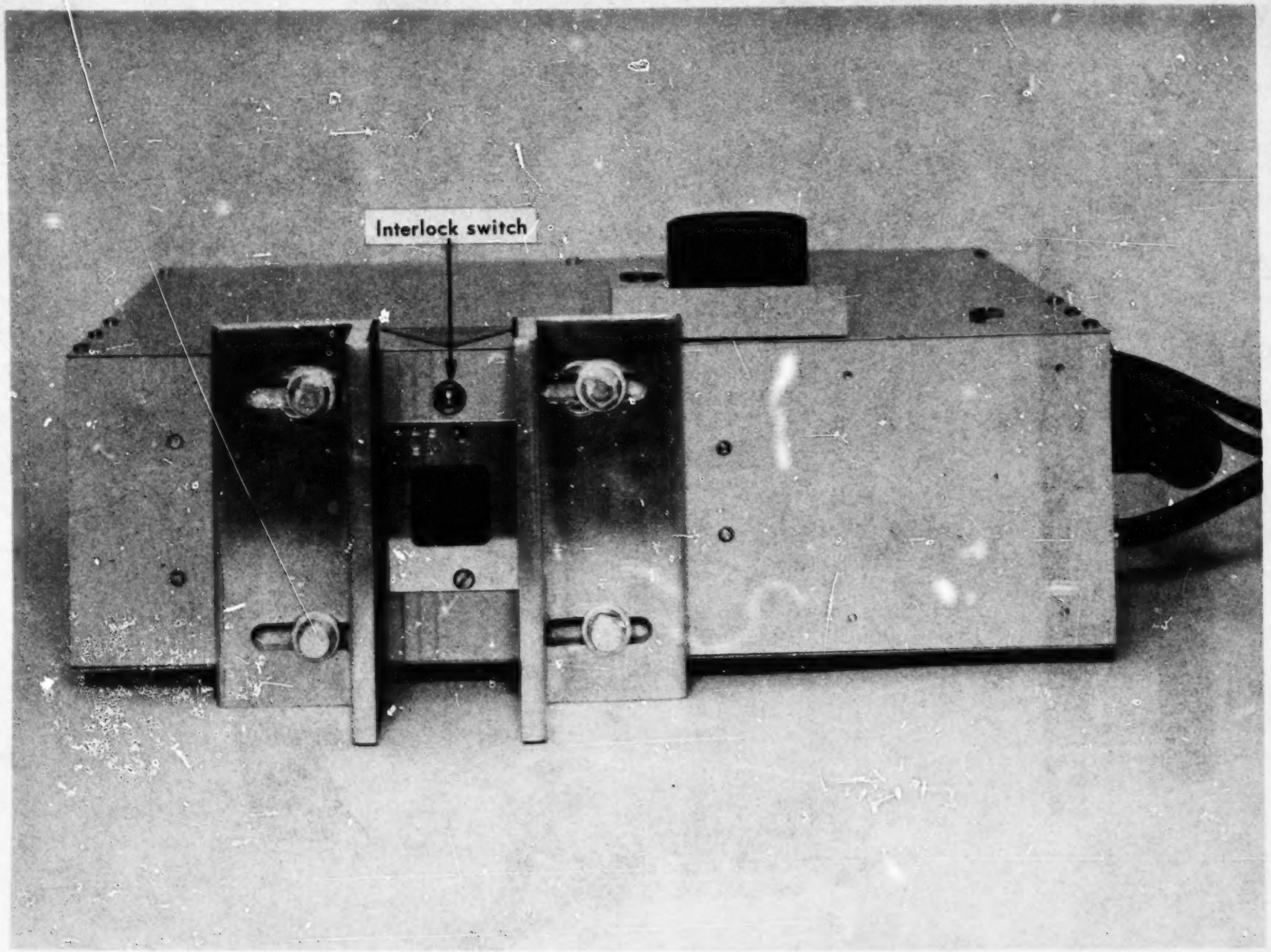


Figure 6. Adjustable shoes mounted for analysis of round stock
(note interlock switch beside beam port)

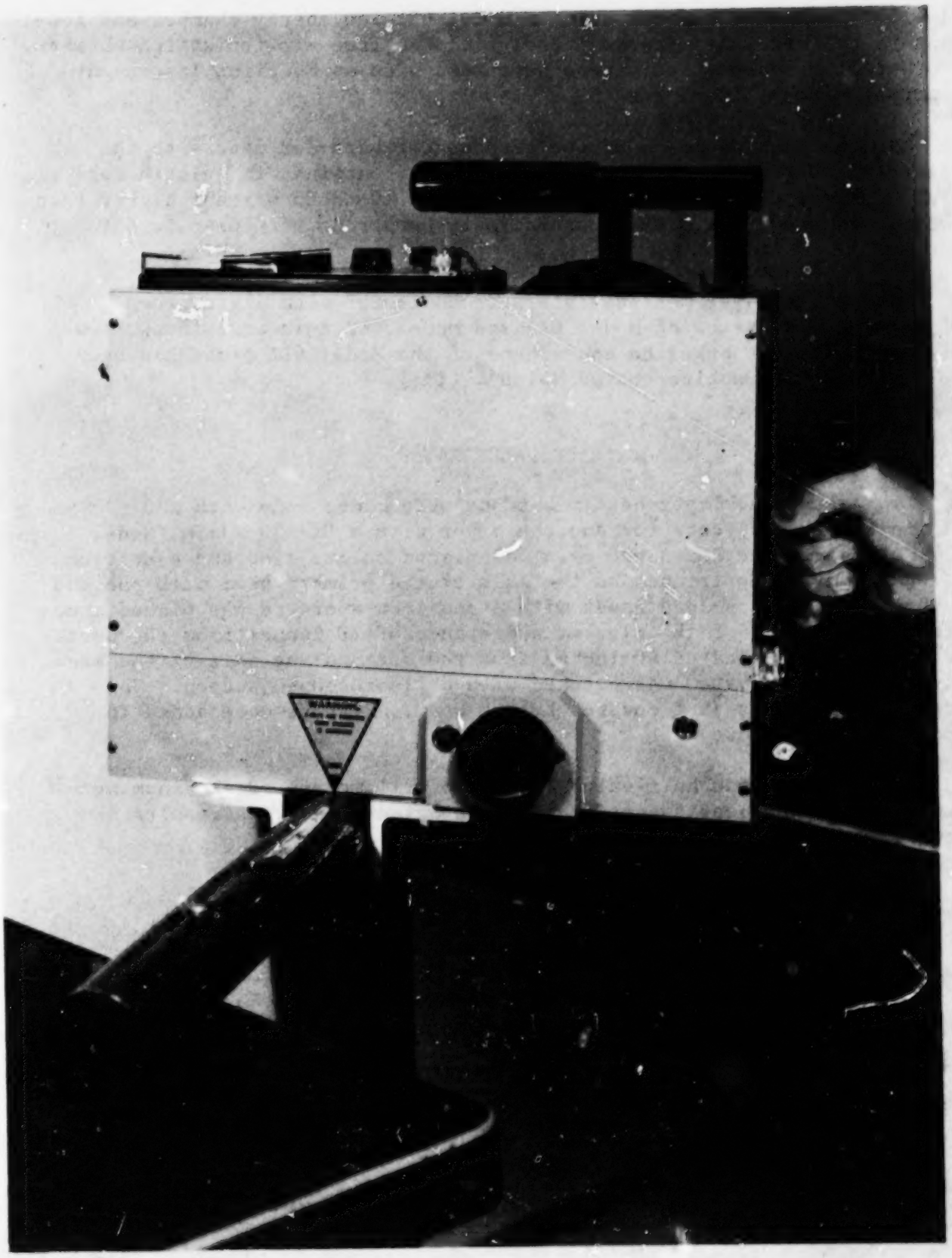


Figure 7. Detector unit positioned for analysis of round bar

Model 570 Condenser R-meter using a Model 651 low-energy chamber and low-exposure calibrations were monitored with the free-air ionization chamber. The thermoluminescent dosimeters were read with an Eberline Instrument Corporation Model TLR-5 reader.

A comparison was made of the response of bare dosimeters to the unfiltered 30-kV beam vs. that of dosimeters contained in gelatin capsules. It was found that the bare rods read 10 to 15 percent higher than the encapsulated rods. As a result, only bare rods were used in this study.

Half-value layer measurements were monitored with a Victoreen Roentgen Rate Meter using Model 613 and Model 612 thin end window, low-energy probes (the bakelite end window of the Model 613 probe had been replaced with a graphite-coated Mylar® film).

4. HALF-VALUE LAYER

Two half-value layer determinations were made: one with a 0 - 1 R/min (Model 613) detector and the other with a 0 - 30 R/min (Model 612) detector. The Portaspec case was placed on its side and a section of lead pipe was positioned on the axis of the primary beam with one end at the beam port. A lead sheet with a one-inch aperture was placed opposite the other end of the pipe at a distance of 20 inches from the port. The detector was located 40 inches from the port on the axis of the beam. Alignment of the system was checked with a fluoroscopic screen. The larger detector was just covered by the beam. Filters were added in front of the aperture.

First and second half-value layers in millimeters of aluminum were found and the homogeneity coefficient was calculated. The results are shown in table 1.

Table 1. Half-value layers and homogeneity coefficient

Detector	1st HVL (mm Al)	2nd HVL (mm Al)	Homogeneity Coefficient
Model 613	0.070	0.162	0.432
Model 612	0.068	0.152	0.447

5. PRIMARY RADIATION MEASUREMENTS

Measurements were made to determine the intensity and profile of the primary beam with no sample in place. The Portaspec case was placed on its side and a sheet of thin cardboard was located such that it was in a plane parallel to the sides of the case and 1/4 inch below the center of the beam port. The sheet was placed off-center to prevent the dosimeters from shielding one another. The dosimeters were spaced at 3-inch intervals on radials 15° apart. The radials are shown in figures 8 and 9.

Dosimeters were exposed using tube currents of 4 mA and 1 mA. The resulting data were used to plot the iso-exposure rate curves presented in figures 8 and 9. These curves show good correlation between the mA settings and the radiation output.

6. SECONDARY RADIATION MEASUREMENTS

6.1 Radiation Within Sample Holder

The sample holder door interlock was bypassed by removing the interlock plug from the side of the Portaspec case. In this configuration exposures are controlled by the thumb switch, allowing the unit to be operated with the sample holder door open.

A film was placed over the open side of the sample holder with the door open (see figures 4 and 5) and an exposure was made. A narrow beam of scattered radiation was observed along the top edge of the doorway which apparently originated from the top of the sample and the sample drawer. A dark area, roughly hyperbolic in shape, appeared on the film near the bottom of the doorway. Dosimeters placed directly beneath the sample and along the floor of the holder just inside the door showed negligible response except for a 27-mR/min reading at 4 mA at one of the doorway locations.

Further experimentation with a fluorescent screen revealed that there is some transmission of radiation through the thin part of the sample drawer around the edge of the sample. This is probably the source of the 27-mR/min reading noted above. However, large exposure rates below the drawer result when there is a crack between the sample and the drawer, allowing a portion of the unattenuated primary beam to pass through. Since the samples may not be much larger than the opening in the drawer, this could be a common condition.

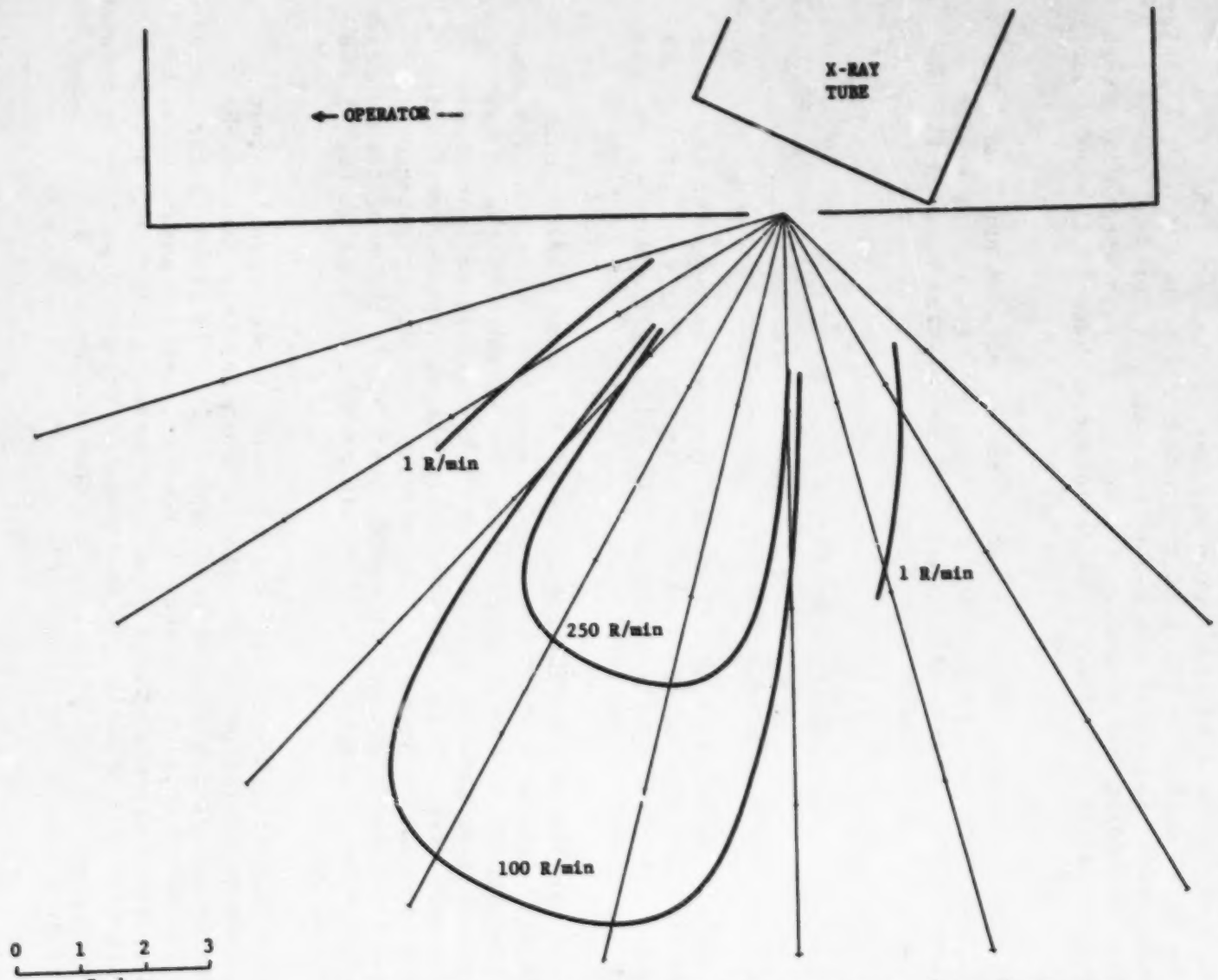


Figure 8. Iso-exposure rate contours from Portaspec operated at 1 mA.
(instrument orientation is the same as in figure 2)

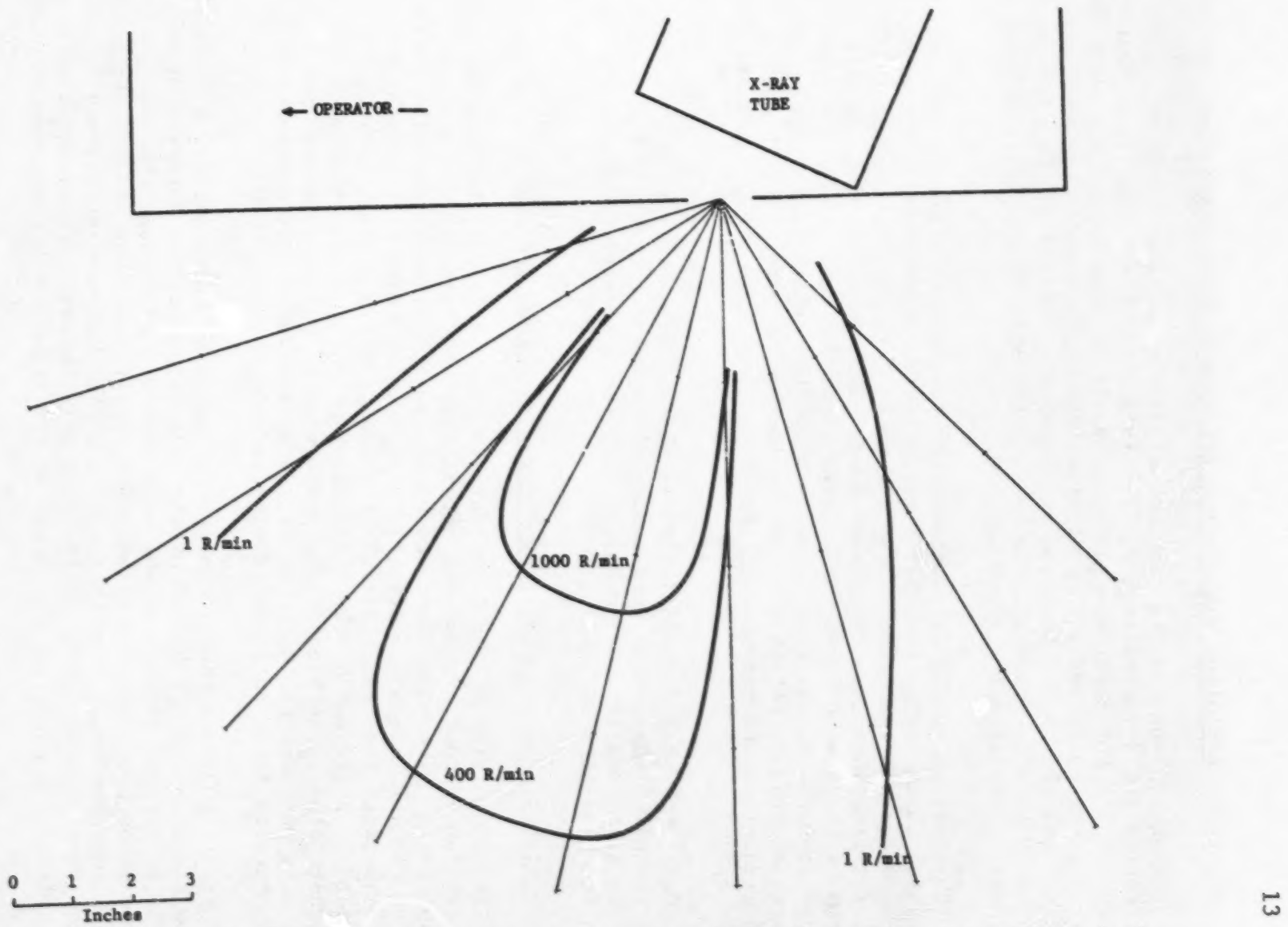


Figure 9. Iso-exposure rate contours from Portaspec operated at 4 mA (instrument orientation is the same as in figure 2)

6.2 Scattered Radiation With Shoes; 2-1/2-inch Brass Pipe

The shoes supplied for use in analyzing round stock were adjusted to accept a 2-1/2-inch-diameter, 1/16-inch-thick brass pipe (see figures 6 and 7). The Portaspec was placed in position over the pipe such that one end of the pipe was flush with the edges of the shoes. A film was held against the end of the pipe and exposed. The end of the pipe was then moved to a position six inches from the side of the case, and another film was placed against it and exposed.

Observation of the films showed the presence of a narrow beam of radiation through the crack between the bottom of the case and the shoes but no discernible penetration of the shoes. The films also showed that the radiation intensity decreases as one moves from the plane of the bottom of the case downward and increases as one moves away from the pipe perpendicularly to its axis (compare with TLD results in table 2). Both effects are the result of self absorption in the pipe. The intensity is also greater on the far side of the pipe relative to the position of the operator.

Using the photographic images as guides, dosimeters were embedded in styrofoam blocks which were positioned against the end of the pipe at the two film locations described above. The dosimeter locations and readings are presented in table 2.

6.3 Scattered Radiation Without Shoes; 2-1/2-inch Brass Pipe

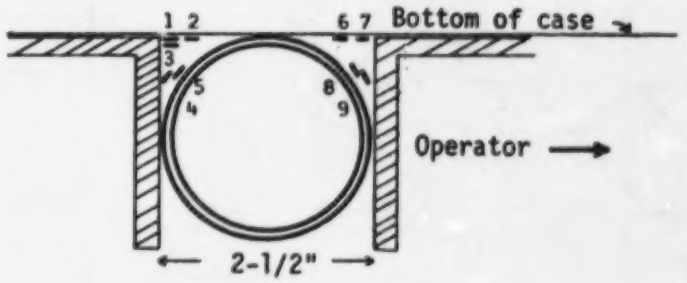
In recognition of the fact that the Portaspec could be used to analyze round stock without the shoes, they were removed for further measurements. The instrument was placed in a horizontal position resting on the 2-1/2-inch-diameter, 1/16-inch-thick brass pipe, which was centered under the beam port in the normal position. Dosimeters were embedded in styrofoam blocks just below the plane of the bottom of the Portaspec case. The blocks were positioned at 45° intervals around the unit at a distance of 10 inches from the beam port. The Portaspec was then operated for a total of 10 minutes at 4 mA.

Figure 10 shows the exposure rates measured approximately 1/8 inch below the plane of the bottom of the case. The maximum intensities are on the line perpendicular to the axis of the pipe through the beam port. At the other positions the intensities are less because of self absorption of the scattered radiation in the pipe. The exposure rates shown here are higher than those shown in table 2 for this reason. The intensities on the far side of the pipe from the operator are higher than those on the near side.

Table 2. Scattered radiation measurements at the end of a brass pipe with the shoes in place

A. End of pipe and dosimeters flush with edges of shoes

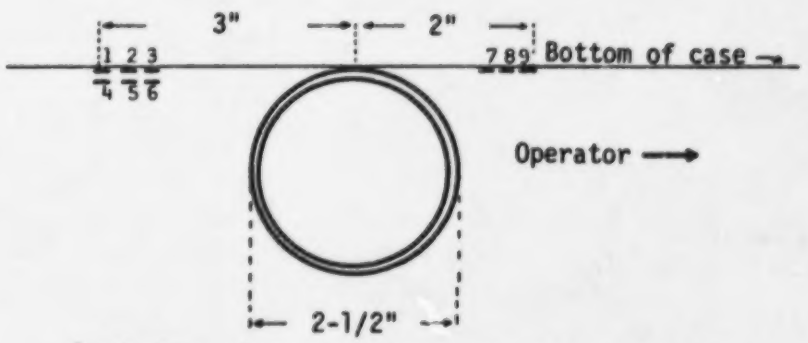
Dosimeter Location	mR/min at 4 mA
1	1478
2	855
3	787
4	21
5	20
6	269
7	472
8	14
9	15



(end view, showing dosimeter placement)

B. End of pipe and dosimeters 6" from side of case

Dosimeter Location	mR/min at 4 mA
1	170
2	167
3	146
4	90
5	86
6	79
7	36
8	39
9	44



(end view, shoes not shown, showing dosimeter placement)

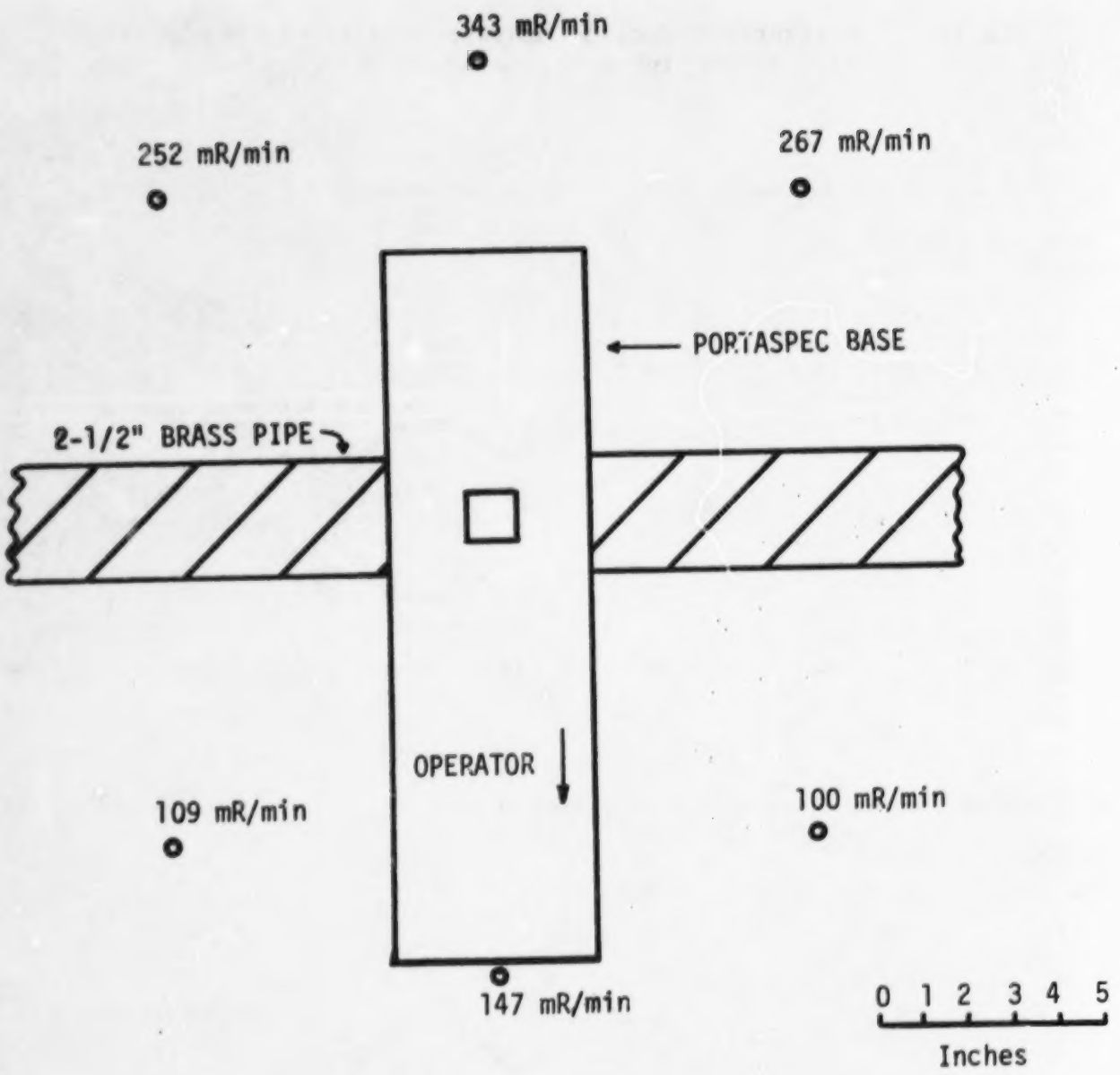


Figure 10. Secondary radiation intensity measured approximately 1/8" below Portaspec® base. Portaspec® operated without shoes at 4 mA.

7. RADIATION RESULTING FROM DISCHARGE OF HIGH-VOLTAGE FILTER CAPACITOR

In the course of aligning the equipment for the half-value layer measurements it was discovered that radiation was still being produced when the exposure switch was released. Investigation showed that the intensity and duration of this radiation depended on the tube current setting. At minimum settings the radiation persisted at a relatively low intensity for a considerable length of time. If the mA was increased, the intensity increased and the duration became very short. It was concluded that this radiation was a result of the high voltage filter capacitor discharging through the X-ray tube when the intended exposure was terminated. It persisted for as much as 2 to 3 minutes at low mA settings and for less than a second at maximum settings.

Two experiments were conducted to evaluate the amount of radiation produced by the capacitor discharge. In the first, dosimeters were placed in front of the center of the beam port, one at a time, allowing only enough room to slide a 1/16-inch piece of lead between the port and the rod. An exposure sufficient to charge the filter capacitor was made with the lead over the port and at the minimum mA setting. The exposure switch was then released and the lead withdrawn in rapid sequence. The capacitor was discharged quickly by increasing the mA control to its maximum setting. The average of five such exposures was 37.0 R with a maximum deviation of about 2 R.

The second experiment was similar to the first except that the capacitor was allowed to discharge at the lowest mA setting for times ranging from 1-1/2 to 3 minutes before the mA was increased. The average of 5 exposures was 28.1 R with a maximum deviation of about 1 R. No deflection of the mA meter needle was observed when the mA was increased after a time exceeding 2-1/2 minutes.

In correspondence with the manufacturer concerning this problem, it was indicated that future units will be provided with a current stabilizer. Part of the function of this device will be to automatically return the X-ray tube filament voltage to a high-current level following each exposure. This will ensure rapid discharge of the high voltage filter capacitor regardless of the current setting during the exposure. The manufacturer has also requested that all existing units be returned for installation of the current stabilizer.

8. OBSERVATIONS AND RECOMMENDATIONS

Many of the safeguards described in "Radiation Safety Recommendations for X-ray Diffraction and Spectrographic Equipment," published by the Bureau of Radiological Health[1], are applicable to the use of this instrument. These are listed in Appendix A.

The following additional comments are offered:

(a) It was observed that the X-ray ON lamp glowed dimly whenever the power supply was turned on. This was felt to be confusing, even though the lamp glowed more brightly when the X-ray tube was energized.

(b) It was discovered that the X-ray tube was energized when the sample holder interlock plug, or any other standard plug, was inserted only part way into the sample holder switchjack and if, at the same time, the switch on the bottom of the case near the beam port was depressed. This presents a radiation hazard in that the unit may be operated continuously with the sample holder door opened, and in that the deadman switching characteristic is lost in other types of operation. Correspondence with the manufacturer has indicated that this condition is corrected by rearrangement of the connections to the plug jack. This modification is being made as the machines are returned to the manufacturer for installation of the current stabilizer (see Section 7).

(c) Consideration should be given to designing the unit for easier installation, adjustment, and removal of the shoes used with round stock, as they proved to be awkward under the present design.

---

[1] "Radiation Safety Recommendations for X-ray Diffraction and Spectrographic Equipment," T. M. Moore and D. J. McDonald, U. S. Department of Health, Education, and Welfare, Bureau of Radiological Health, Rockville, Maryland, October 1968.

APPENDIX A

RADIATION SAFETY RECOMMENDATIONS FOR PORTABLE X-RAY SPECTROGRAPH[1]

Administrative Responsibilities

1. For each facility using a portable X-ray spectrograph, a person shall be appointed to be responsible for radiation safety. This person, designated the radiation protection supervisor or radiation safety officer, shall be responsible for the following:

> Comment: The radiation protection supervisor (who may be the operator) should be familiar with the basic principles of radiation protection and the particular hazards associated with the operation of X-ray diffraction and spectrographic equipment, although he may consult with appropriate experts for detailed advice. The radiation protection supervisor should clearly have authority over matters involving radiation safety, and ideally should be a member of the management staff.

a. Insuring that operational procedures pertaining to radiation safety are established and carried out so that the radiation exposure of each worker is kept as far below the maximum permissible dose equivalent as is practical.

> Comment: The primary objective in establishing maximum permissible dose equivalent values for occupational exposure is to keep the exposure of the radiation worker well below a level at which adverse effects are likely to be observed during his lifetime. Another objective is to minimize the incidence of genetic effects for the population as a whole. While the risk to individuals exposed to the maximum permissible dose equivalent is considered to be very small, the risk increases gradually with the dose received. For this reason, it is desirable to keep radiation exposures as low as is practical with due consideration to feasibility and efficiency of operation.

b. Providing instruction in safety practices for all personnel who work with or near the portable X-ray spectrograph.

c. Maintaining a system of personnel monitoring.

---

[1] Adapted from "Radiation Safety Recommendations for X-ray Diffraction and Spectrographic Equipment," T. M. Moore and D. J. McDonald, U. S. Department of Health, Education, and Welfare, Bureau of Radiological Health, Rockville, Maryland, October 1968.

d. Arranging for establishment of radiation control areas, including placement of appropriate radiation warning signs and/or devices.

e. Providing for radiation safety inspection of the portable X-ray spectrograph.

f. Investigating any case of abnormal radiation exposure to personnel and taking remedial action, if necessary.

g. Complying with all applicable Federal, State, and local rules and regulations.

2. No individual shall be permitted to act as an operator of the portable X-ray spectrograph until such person has:

a. Received an acceptable amount of training in radiation safety as approved by the radiation protection supervisor.

b. Demonstrated competence to use the machine and radiation survey instruments which will be employed.

c. Received the approval of the radiation protection supervisor.

3. The operator of the portable X-ray spectrograph shall be responsible for all operations associated with that equipment, including radiation safety. In particular he shall:

a. Keep radiation exposure to himself and others as low as is practical.

b. Be familiar with safety procedures as they apply to each machine he operates.

c. Wear personnel monitoring devices.

d. Notify the radiation protection supervisor of known or suspected abnormal radiation exposures to himself or others.

4. The operator should be in immediate attendance at all times when the equipment is in operation or connected to a source of electricity. Deviations from this practice should be cleared through the radiation protection supervisor.

5. When not in operation, the equipment shall be secured in such a way as to be accessible to, or operable by, only authorized personnel.

6. The portable X-ray spectrograph should be placed and used in a room separate from other work areas, whenever possible.

Operating Procedures

7. No person shall permit any part of his body to be exposed to the primary beam.

8. Only trained personnel, as approved by the radiation protection supervisor, shall be permitted to install, repair, or make other than routine modifications to the portable X-ray spectrograph.

9. Written emergency procedures pertaining to radiation safety shall be established for each facility by the radiation protection supervisor and shall be posted in a conspicuous location near the storage area of the unit or on the equipment itself. These should list telephone numbers of a physician and the radiation protection supervisor and, as a minimum should include instructions for the following actions to be taken in case of a known or suspected accident involving radiation exposure:

   a. Notifying radiation protection supervisor.

   b. Arranging for medical examination, being sure to notify the examining physician that exposure to low energy X-rays may have occurred.

10. If, for any reason, it is temporarily necessary to alter safety devices, such as by passing interlocks or removing shielding, such action shall be:

   a. Specified in writing, approved by the radiation supervisor, and posted on or near the spectrographic unit so that other persons will know the existing status of the machine.

   b. Terminated as soon as possible.

11. Radiation exposure to individuals, either within a radiation controlled area or in its environs, shall be so controlled that the maximum permissible dose equivalent values as set forth by the National Council on Radiation Protection and Measurements, or Federal, State, and local rules and regulations, are not exceeded.

Personnel Monitoring

12. Operators of the portable X-ray spectrograph should be provided with finger or wrist radiation monitoring devices. The supplier of the monitoring device should be notified of the energy of the monitored radiation.

   Comment: The decision as to the need for personnel monitoring devices should be made after first evaluating the likelihood that the operator will be working in close proximity to the primary radiation beam, taking into account procedures such as beam alignment and equipment maintenance. The monitoring

device should be so located that the body part nearest the primary beam is monitored. For example, if the operator sets up an experiment working primarily with his right hand, a wrist or finger monitor should be worn on that hand. Monitoring devices worn on the chest or abdomen may provide an indication of the amount of stray radiation to the whole body. It is important to note that the cross sectional area of the primary radiation beam is usually small and that the monitoring device may not indicate the maximum primary or stray radiation exposure to the operator.

13. The personnel monitoring data shall be retained as a permanent record by the radiation protection supervisor and shall be available for examination by all personnel concerned.

Area Monitoring

14. Radiation protection surveys should include monitoring for stray radiation in the immediate vicinity of the X-ray apparatus.

Comment: These surveys, which may be performed by the operator or the radiation protection supervisor, may be necessary for the proper placement of shielding or for the location of barriers which limit the entry of persons into radiation controlled areas.

Geiger-Mueller portable survey instrument may be valuable for locating stray radiation, although the results are not necessarily quantitative. If accurate exposure measurements are desired, the survey instrument should be calibrated with a source of low-energy X rays. Consideration should also be given to possible monitoring errors due to the cross sectional area of the monitored radiation beam being smaller than the sensitive area of the survey instrument. Defects in shielding may sometimes be best detected by means of films.

Safety Engineering

15. A sign or label bearing the words "Caution - Radiation - This Equipment Produces X Radiation When Energized - To Be Operated Only By Qualified Personnel," or words having similar intent, shall be placed near any switch which energizes an X-ray tube. The sign or label shall use the conventional radiation caution colors (magenta on a yellow background) and shall bear the conventional radiation symbol.

16. A sign or label bearing the words "Caution - High Intensity X-ray Beam," or words having similar intent, shall be placed on or adjacent to each X-ray tube housing. It should be located so as to be clearly visible to any person who may be working in close proximity to the primary radiation beam.

17. A red or magenta warning light with the notation "X-ray On," or equivalent, shall be located on the control panel and shall light only when the X-ray tube is activated.

APPENDIX B
MANUFACTURER'S SPECIFICATIONS

Manufacturer	:	Pitchford Manufacturing Corporation 1901 Painters Run Road, Pittsburgh, Pa.
Trade Name	:	Portaspec®
Bragg Angle Range, 2 θ	:	13^{o} - 89^{o}
Element Range K α	:	22 - 51 (Ti to Sb)
Element Range L α	:	56 - 92 (Ba to U)
Analyzing Crystal	:	LiF (Others if necessary)
Dial Calibration	:	Degrees 2 Theta and Elements
X-ray Tube	:	Beryllium Window - W Target
X-ray Tube Voltage	:	30 kV - Constant Potential - Fixed
X-ray Voltage Regulation	:	± 1% for ± 10% line
X-ray Tube Current	:	1 to 4 mA - Adjustable
X-ray Current Regulation	:	± 1% for ± 10% line
High Voltage Generator	:	30 kV Constant Potential, Epoxy filled, 0.3% ripple
External Cables	:	Interconnecting 9 ft., Line Cord 8 ft., 3 Wire
Detector	:	Geiger Counter - High and Low Energy
Ratemeter	:	Solid State - operates 100 hours continuously on two D Cells, provides pure DC voltage for stability
Ratemeter Ranges	:	10, 100 and 1000 counts per second, full scale
Time Constants	:	1.5 sec., 5 sec. and 15 sec.,
Controls	:	Line and filament switches - solid state variable mA control

Meters	:	X-ray tube current (mA) and frequency readout
Fuses	:	Line, High Voltage and Filament
Lamps	:	Ground, Line, Filament, High Voltage
Supply Requirements	:	110 Volt, 60 cycle, single phase, 220 Watts (220 Volt, 50 cycle, single phase on request)
Dimensions:		
Probe Unit	:	15" high x 17-1/2" long x 6" wide including handles
Generator	:	13" high x 14-3/4" deep x 21-1/2" wide
Weight:		
Probe Unit	:	23 lbs. net
Generator	:	100 lbs. net

The ABSTRACT CARDS below are designed to facilitate document retrieval using Coordinate Indexing. They provide space for an accession number (to be filled in by the user), suggested key words, bibliographic information, and an abstract.

The Coordinate Index concept of reference material filing is readily adaptable to a variety of filing systems. Coordinate Indexing is described in the publication "IBM Data Processing Techniques - Index Organization for Information Retrieval" (C 20-8062). Copies are available through IBM Branch Offices.

The cards are furnished in triplicate to allow for flexibility in their use (e.g., author card index, accession number card index).

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC PORTABLE X-RAY SPECTROGRAPH
Ray C. Woodcock; February 1970; DEP 70-4; DEP, BRH, EHS, PHS, DHEW

Accession No.

Measurements made to determine physical and operating characteristics of a portable X-ray spectrograph are described and the results reported. The unit was designed for on-the-spot warehouse sorting and checking of specifications, identification and sorting of scrap-metals, and many other uses in mining and chemical plants. The tests reported here consist primarily of an analysis of the primary X-ray beam and of scattered radiation under various conditions of use. Some comments and recommendations relating to radiation safety in the use of the equipment are made.

(over)

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC PORTABLE X-RAY SPECTROGRAPH
Ray C. Woodcock; February 1970; DEP 70-4; DEP, BRH, EHS, PHS, DHEW

Accession No.

Measurements made to determine physical and operating characteristics of a portable X-ray spectrograph are described and the results reported. The unit was designed for on-the-spot warehouse sorting and checking of specifications, identification and sorting of scrap-metals, and many other uses in mining and chemical plants. The tests reported here consist primarily of an analysis of the primary X-ray beam and of scattered radiation under various conditions of use. Some comments and recommendations relating to radiation safety in the use of the equipment are made.

(over)

EVALUATION OF A NORELCO-PITCHFORD PORTASPEC PORTABLE X-RAY SPECTROGRAPH
Ray C. Woodcock; February 1970; DEP 70-4; DEP, BRH, EHS, PHS, DHEW

Accession No.

Measurements made to determine physical and operating characteristics of a portable X-ray spectrograph are described and the results reported. The unit was designed for on-the-spot warehouse sorting and checking of specifications, identification and sorting of scrap-metals, and many other uses in mining and chemical plants. The tests reported here consist primarily of an analysis of the primary X-ray beam and of scattered radiation under various conditions of use. Some comments and recommendations relating to radiation safety in the use of the equipment are made.

(over)

KEY WORDS:
X-ray spectrograph
Radiation safety
X-ray
Industrial radiation

KEY WORDS:
X-ray spectrograph
Radiation safety
X-ray
Industrial radiation

KEY WORDS:
X-ray spectrograph
Radiation safety
X-ray
Industrial radiation